IND Cubesat Briefing/Technical Exchange
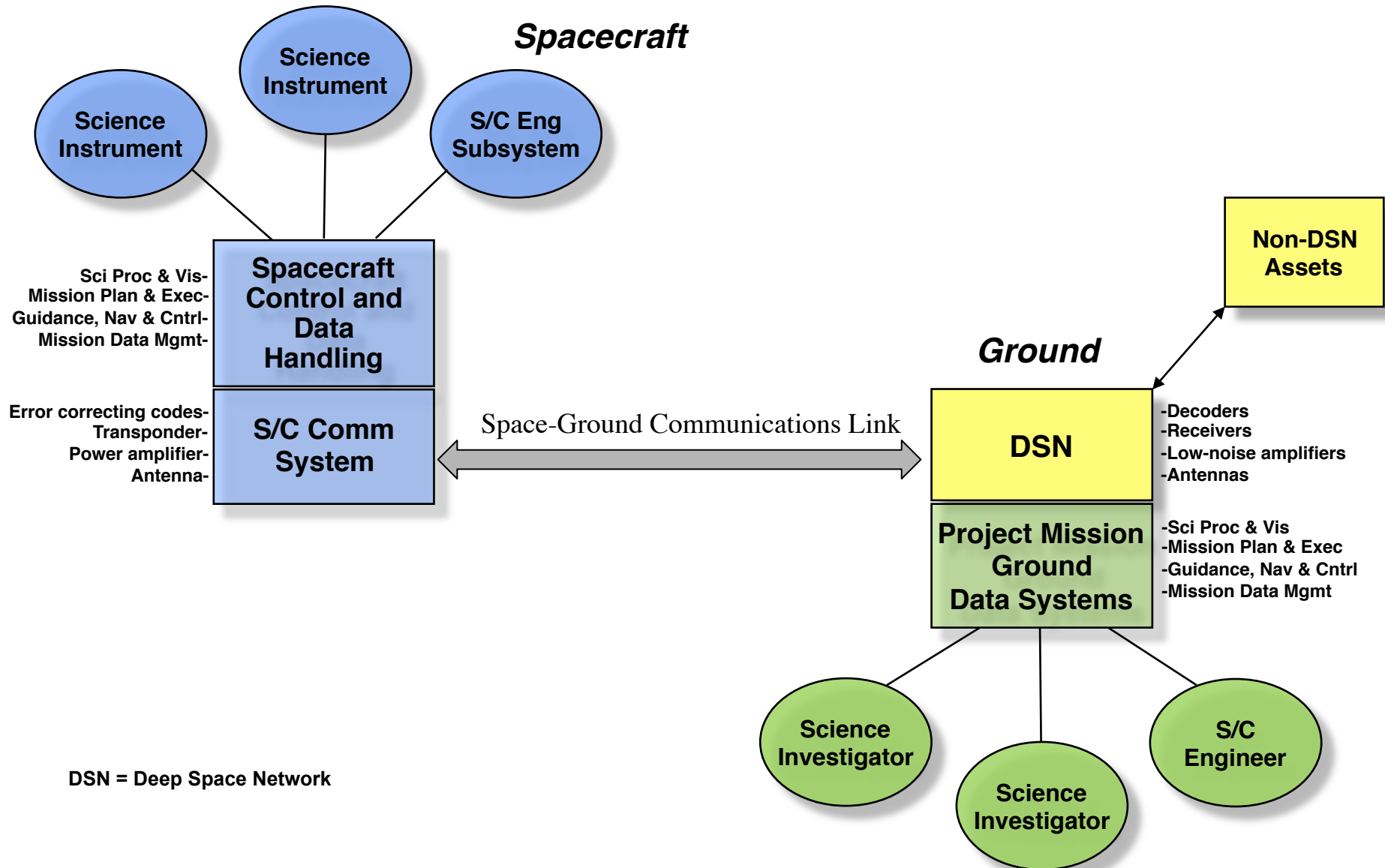# 10 November 2015

DSN Commitments

Steve Waldherr

The DSN's Role in
Space-Ground Communications

Spacecraft

Science Instrument

Science Instrument

S/C Eng Subsystem

Sci Proc & Vis-
Mission Plan & Exec-
Guidance, Nav & Cntrl-
Mission Data Mgmt-

Spacecraft Control and Data Handling

Error correcting codes-
Transponder-
Power amplifier-
Antenna-

S/C Comm System

Space-Ground Communications Link

Non-DSN Assets

Ground

DSN

-Decoders
-Receivers
-Low-noise amplifiers
-Antennas

Project Mission Ground Data Systems

-Sci Proc & Vis
-Mission Plan & Exec
-Guidance, Nav & Cntrl
-Mission Data Mgmt

Science Investigator

Science Investigator

S/C Engineer

DSN = Deep Space Network

DSN Service Overview

- The DSN is optimized to conduct telecommunication and tracking operations with multiple deep space scientific missions (category B missions)
  - The DSN also supports near-Earth missions above low earth orbit, including those at lunar distances, the Sun-Earth LaGrange points, and in highly elliptical Earth orbits (category A missions)

- The DSN offers services to a wide variety of mission customers, at multiple frequency bands, through all phases of a mission's lifetime

Customers	**Mission Phases**
• NASA • Other Government Agencies • International Partners	• Launch and Early Orbit Phase (LEOP) • Cruise • Orbital • In-situ
Mission Orbits	**Frequency Bands**
• Geostationary or Geosynchronous Earth Orbit (GEO) • Highly Elliptical • Lunar • La Grange • Earth Drift-Away • Planetary	• S-Band (2 GHz) • X-Band (7, 8 GHz) • Ka-Band (26, 32 GHz)

DSN: The Big Picture
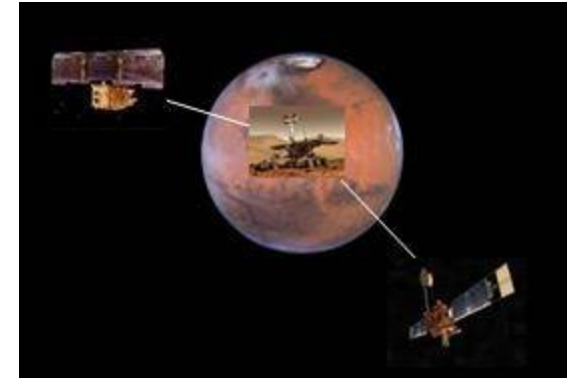
Spacecraft Operations

DSN Antenna

WAN

DSCC Signal Processing Center (SPC) located at the DSN complex

JPL Deep Space Operations Center (DSOC)

Mission Operations Center (MOC)

DSN Resources

- The DSN consists of Deep Space Communications Complexes with ground stations located near
  - Madrid, Spain
  - Canberra, Australia
  - Goldstone, California

- At each complex there are a variety of antennas, including 34-meter Beam Wave Guide (BWG), 34-meter High Efficiency (HEF), and 70-meter antennas

- In addition, the DSN supports RF testing using the following facilities
  - Development and Test Facility (DTF-21), located near JPL
  - Compatibility Test Trailer (CTT-22), able to come to the spacecraft site
  - DSN test facility (MIL-71), located at the Kennedy Space Center, Florida

DSN Resources
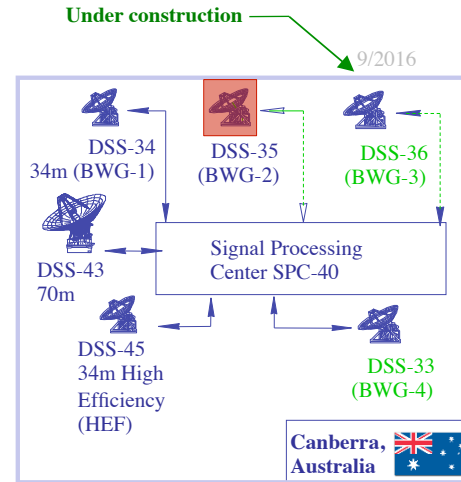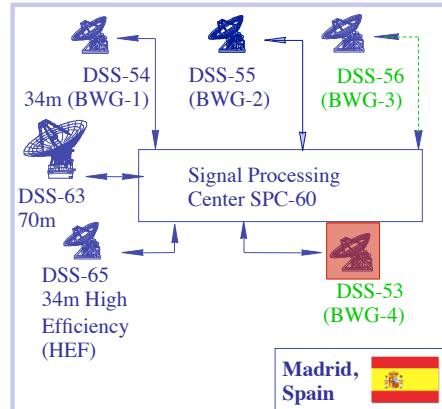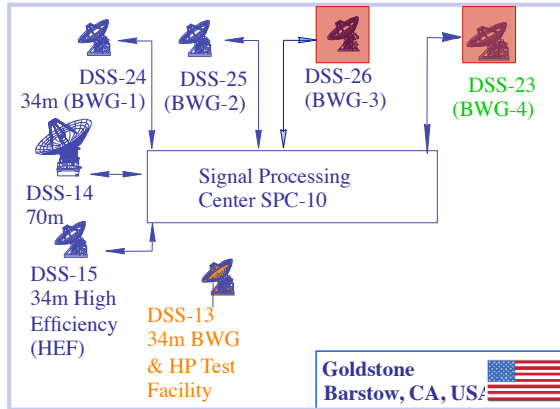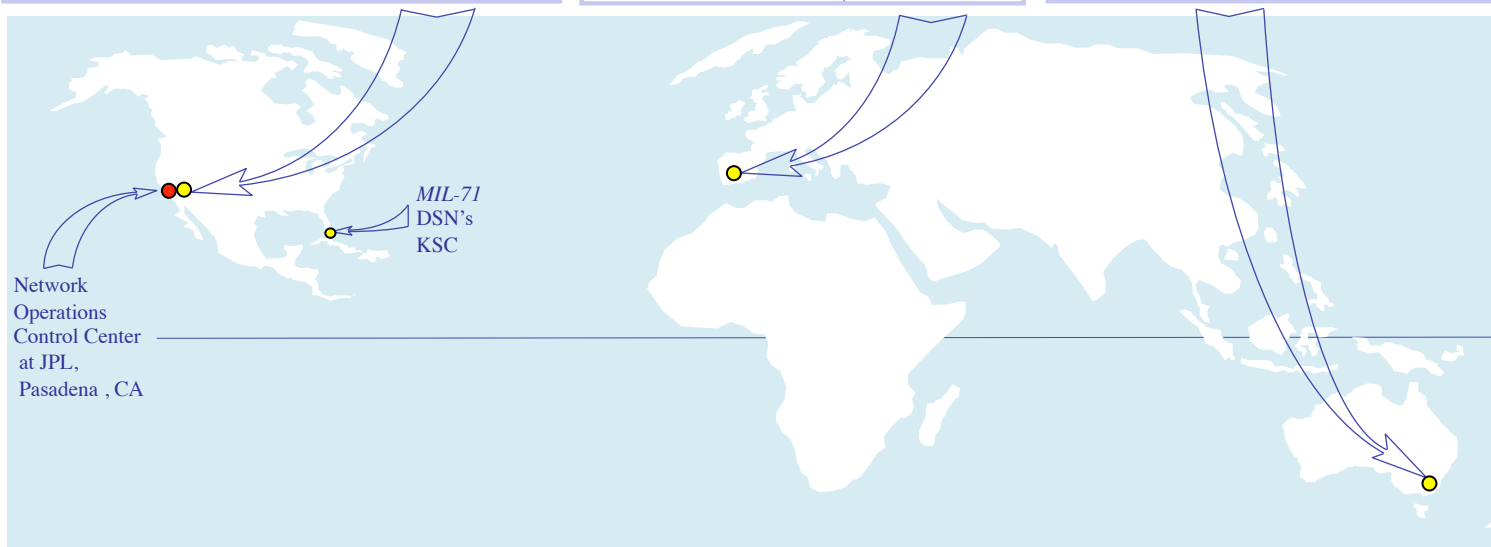
What Services the DSN Provides

As described in the DSN Services Catalog (820-100), the DSN provides:

- Engineering Support
  - System Engineering
  - Advanced Mission Planning
  - Emergency Mission Operations Center
  - Radio Frequency (RF) Compatibility Test
  - Mission System Test
  - Spectrum and Frequency Management
  - Spacecraft Search

- DSN services
  - Standard
  - Custom

Characteristics of DSN Standard Data Services

- "Pick & Choose"
  - DSN standard data services are independent of each other

- "Plug & Play"
  - DSN standard data services are multi-mission in nature and generally require table adaptations
  - No development is required on the part of the DSN beyond configuration, parameter updates, mission service validations and interface testing
  - Development on the customer's side is limited to using the standard service and meeting its interfaces

- Standard Interfaces
  - DSN-provided data services are accessed via well-defined, standard data and control interfaces
    - the Consultative Committee for Space Data Systems (CCSDS),
    - the Space Frequency Coordination Group (SFCG),
    - the International Telecommunication Union (ITU),
    - the International Organization for Standardization (ISO),
    - de facto standards widely applied within industry,
    - and common interfaces specified by the DSN
  - Data service interface standards enable interoperability with similar services from other providers
  - Mitigates the need for additional development effort on the part of both the DSN and the customer
  - Maximizes the customer's opportunities to reuse
  - Helps keep costs down

Standard Data Services

- **Command Services**
  - Forward Space Link Extension (SLE)
    - Command Link Transmission Unit (CLTU) Radiation

- **Telemetry Services**
  - Return Space Link Extension (SLE)
    - Frame
    - Relay Service
    - Beacon Tone

- **Tracking Services**
  - Validated Radio Metric Data
  - Delta-DOR (Differential 1-way ranging)

- **Calibration and Modeling Services**
  - Platform Calibration
  - Media Calibration

- **Radio Science Services**
  - Experiment Access
  - Data Acquisition

- **Service Management**
  - Allocation and scheduling of assets
  - Configuring, monitoring, and controlling the DSN asset
  - Reporting service execution results

DSN Mission Interface Document Tree

DSN Controlling Documents

DSN Service Catalog 820-100	DSN Telecom Link Design Handbook 810-005	DSN Software Interface Specs 820-13

Generic Mission Document

DSN Mission Service Interfaces, Policies and Practices (MSIPP) 875-0001

Mission-Specific Documents (signed by Project and DSN)

Service Agreement (DSA/PSLA) 870-xxx

DSN- Operations Interface Control Document (OICD) 875-xxx

DSN Internal Documents Mission-Specific

DSN Mission specific Compat Test Plan, Procedures, Report 872-xxx	DSN Network Operations Plan Mission Specific 871-xxx

DSN-Mission Commitment Documentation

The MIM and the Mission work together to create the following:

- **DSN Service Agreement** (870 series)
  - High-level statement of standard services, cost, support duration
  - Defines custom services and cost (if any)
  - Final for MOS CDR

- **Operational Interface Control Document** (875 series)
  - Parameter values to instantiate and operate
  - Uses info typically found in Mission documents:
    - Mission Plan
    - Navigation Plan
    - Mission Ops Scenario
    - Radio Frequency Interface Control Document (RFICD)
      - Including telecommunication parameters and link budget information
  - Preliminary ready for Mission Critical Design Review (CDR)
  - Final ready for Operational Readiness Review (ORR)

Example of a typical NASA Project Lifecycle

NASA Phases	FORMULATION			APPROVAL / IMPLEMENTATION		
Project Lifecycle Phases	**Pre-Phase A:** Advanced Studies	**Phase A:** Mission & Systems Definition	**Phase B:** Preliminary Design	**Phase C:** Design & Build	**Phase D:** ATLO	**Phase E:** Operations
Major Project Reviews	△ MCR	△ SRR △ MDR	△ PMSR △ Project PDR	△ Project CDR △ MOS PDR △ ATLO Readiness Review △ MOS CDR	△△ ORR & MRR	△ CERR
Documents		△ LOC	△ DSA (draft)*	△ DSA (prel)* △ DSA* △ OICD (prel)	△ OICD	

*DSA is a JPL gate product

Legend
ATLO: Assembly, Test, Launch, and Operations
CERR: Critical Events Readiness Review
CDR: Critical Design Review
DSA: DSN Service Agreement
LOC: Letter of Commitment (competed missions only)
MCR: Mission Concept Review (assigned missions only)

MDR: Mission Definition Review (assigned missions only)
MRR: Mission Readiness Review
OICD: DSN Mission Operations Interface Control Document
ORR: Operations Readiness Review
PDR: Preliminary Design Review
PMSR: Project Mission System Review (competed missions only)
SRR: System Requirements Review

Radio Frequency (RF) Compatibility Testing

- The DSN requires pre-launch RF compatibility testing as a means to eliminate post-launch anomalies and expensive troubleshooting
  - Testing validates the spacecraft radio frequency subsystem and its telecommunications capabilities as they interact with DSN RF and data systems
  - Missions may opt to conduct end-to-end telemetry and command data flow tests following the successful completion of RF Compatibility tests
  - If no RF compatibility testing is conducted, the DSN requires a waiver from the Customer

- RF Compatibility Testing Schedule
  - RF compatibility testing should be planned for ~1 year prior to launch, but may take place <u>no later than</u> 6 months prior to launch

- Additional Validation Info
  - See **DSN Mission Service Interfaces, Polices, and Practices (MSIPP)** (875-0001) for additional detail on RF Compatibility tests, as well as other validation tests to be performed with the DSN

DSN Costs

DSN Aperture Fee: The Aperture Fee is used for full cost accounting purposes and is normally not an expense to a NASA sponsored mission. As determined by NASA, some missions will be considered reimbursable, and will be charged for the DSN Aperture. The Aperture fee is based on the specific antenna(s) used, and the number and duration of tracking passes. The base fee is weighted, and increases as the number of contacts per week increase. The fee also included the DSN station setup and teardown for each contact (track). The aperture fee accounts for the following standard data services and engineering support:

Data Services

- Command Services
- Telemetry Services
- Tracking Services
- Calibration and Modeling Services

- **Radio Science Services**
- **Initial Acquisition Provision**

Engineering Support

- Systems engineering
- Advance mission planning
- Emergency Control Center (ECC)

- **Mission system test**
- **Spectrum and frequency management**
- **Spacecraft search**

DSN Costs (cont.)

Additional Fees - The following services are charged to all NASA missions according to usage:

- **First Use**: The costs for development of enhancements and new capabilities that extend beyond the DSN Project baseline budget and scope are charged to the requiring mission.

- **Mission Interface Manager (MIM):** Missions will be charged for MIM support for the planning and execution of project critical events.

- **Telemetry Tracking & Command (TTC) Mission-Specific Services**: Engineering costs for adapting and validating TTC data delivery systems for an individual mission are charged to that mission. All missions will require some TTC adaptation.

- **DSN Operations**: Costs for the operations of DSN capabilities not included in the aperture fee are funded by the using mission.

- **Ground Communications**: Ground communication installation and sustaining costs (circuits, routers, voice) for mission extensions to off-site (non-JPL) locations are charged to the mission.

- **Radio Frequency (RF) Compatibility Testing:** Costs for RF compatibility testing using Development Test Facility (DTF-21), Compatibility Test Trailer (CTT-22) and MIL-71 test facility at Kennedy Space Center are charged by the day, and the resource being used.

First Steps Towards DSN Support

- Task Plan
  - Funds must be transferred to the DSN to complete mission-specific work in preparation for support. This is accomplished using a task plan that is signed by NASA, the DSN, and the mission's agency (if not NASA).
  - For non-NASA missions, the task plan cannot be completed until there is a valid Space Act Agreement (SAA) in place.
  - The DSN is responsible for creating the task plan. The MIM works with the Mission to define the scope of work, and then works with the DSN to estimate costs. With this information, the task plan is then written.
  - Due to the contractual nature of the document, it takes an average of 6-8 weeks to write the task plan, get it signed, and have the funds transferred.

- Spectrum Management
  - For federal agencies, JPL's Spectrum Management office will secure the frequency authorization for Deep Space frequencies, and the Goddard Spectrum Managements office for Near Earth frequencies.
  - In addition, each DSN station supporting a mission must have an uplink transmission license. The DSN is responsible for obtaining station transmission licenses.
  - For non-federal agency missions, the FCC regulates the use of radio frequencies using a spectrum management process called frequency allocation. It is the mission's responsibility to obtain the frequency allocation from the FCC.

Key Personnel

- **DSN Mission Interface Manager (MIM)**
  - The mission's agent to optimize DSN technical support
  - Negotiates, and document DSN services, interfaces and costs
  - Prepares, coordinates the DSN for critical events
  - Manages DSN services for life of the mission

- **DSN Project Data System Engineer (PDSE)**
  - DSN processing lead for data delivery

- **DSN Network Operations Project Engineer (NOPE)**
  - operational lead for DSN support
  - supported by team of operators, analysts (NOA), engineers (CDE, OE)

- **Project Mission Manager**
  - interacts with DSN to prepare and execute telecomm

- **Project Scheduler**
  - the mission's agent to plan and negotiate DSN tracking schedule

DSN Mission Interface Management

- DSN Mission Support Definition and Commitments Office (9021) functions as the service provider gateway for all projects
    - DSN Mission Interface Manager (MIM) is responsible for interfacing with the customers from pre-project planning through design, development, testing, flight operations, and closeout

  Mission Interface Manager Contact Info:

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  (818) 235-4162 cell

Important References

- **DSN Commitments Office Website**
  - http://deepspace.jpl.nasa.gov/advmiss/index.html

- **DSN Mission Service Interfaces, Polices, and Practices (MSIPP)** (875-0001)
  - http://deepspace.jpl.nasa.gov/advmiss/proposal preparation/#

- **DSN Services Catalog** (820-100)
  - http://deepspace.jpl.nasa.gov/advmiss/proposalpreparation/#

- **DSN Telecommunications Link Design Handbook** (810-005)
  - http://deepspace.jpl.nasa.gov/dsndocs/810-005/index.cfm

- **DSN External Interface Specification** (820-013)
  - https://jaguar.jpl.nasa.gov/

BACKUP

DSN Station Capabilities

DSS No.	Antenna Type	Location	Agency / Ops Org	S-Band Uplink Frequency (MHz)	S-Band Downlink Frequency (MHz)	X-Band Uplink Frequency (MHz)	X-Band Downlink Frequency (MHz)	Ka-Band Downlink Frequency (MHz)
14	70m	Goldstone, California	NASA/DSN	2110 - 2118	2270 - 2300	7145 - 7190	8400 - 8500	-
15	34HEF	Goldstone, California	NASA/DSN	2025 – 2120	2200 - 2300	7145 - 7190	8400 - 8500	-
24	34B1	Goldstone, California	NASA/DSN	2025-2120	2200 - 2300	7145 - 7190, 7190 - 7235	8400 - 8500	25500 - 27000
25	34B2	Goldstone, California	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
26	34B3	Goldstone, California	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
34	34B1	Canberra, Australia	NASA/DSN	2025-2120	2200 - 2300	7145 - 7190, 7190 - 7235	8400 - 8500	25500 - 27000, 31800 - 32300
35 (Oct 2014)	34B2	Canberra, Australia	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
36 (Oct 2016)	34B3	Canberra, Australia	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
43	70M	Canberra, Australia	NASA/DSN	2110 - 2120	2270 - 2300	7145 - 7190	8400 - 8500	-
45	34HEF	Canberra, Australia	NASA/DSN	2025-2110	2200 - 2300	7145 - 7190	8400 - 8500	-
54	34B1	Madrid, Spain	NASA/DSN	2025 - 2110 2110 - 2120*	2200 - 2300	7145 - 7190, 7190 - 7235	8400 - 8500	25500 - 27000, 31800 - 32300
55	34B2	Madrid, Spain	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
63	70m	Madrid, Spain	NASA/DSN	2110-2118*	2270 - 2300	7145 - 7190	8400 - 8500	-
65	34HEF	Madrid, Spain	NASA/DSN	2025 - 2110	2200 - 2300	7145 - 7190	8400 - 8500	-

Contact Information

- MIMs
  - Glen Elliott, gelliott@jpl.nasa.gov
  - Stefan Waldherr, stefan.waldherr@jpl.nasa.gov